A Comparative Theory of Non-Integration, Integration, and the Decentralized Firm

著者	Suzuki Yutaka
出版者	Institute of Comparative Economic Studies, Hosei University
journal or publication title	Journal of International Economic Studies
volume	25
page range	3-28
year	2011-03
URL	http://hdl.handle.net/10114/7051

Journal of International Economic Studies (2011), No.25, 3–28

A Comparative Theory of Non-Integration, Integration, and the Decentralized Firm

Yutaka Suzuki
Faculty of Economics, Hosei University

Abstract

We present a comparative theory of "Non-Integrated", "Integrated", and "Decentralized" firms, and study the optimal scope of a firm and the assignment of different types of managers to different types of firms, in an IO setting with R&D and production activities. "Non-integrated firms" fail to take into account the externalities that managers' decisions have on other firms. While an "integrated firm" internalizes these externalities, it does not take into consideration the "private benefits" of managers. The "decentralized firm" works as a hybrid of these two structures. We also interpret our model from the viewpoint of the allocation of formal authority, and uncover some interesting economic implications.

Key words: Non-Integration, Integration, Decentralized Firm, Private Benefit, Internalization of Externalities.

JEL classification: D23, L22

1. Introduction

1.1. The Importance of Our Research: Real World Examples

We shall start with some anecdotes involving U.S. and Japanese firms that provided the motivation for this paper[1].

In the early1920s, before Alfred Sloan's reorganization of General Motors, the manufacturing managers of Buick, Cadillac, Chevrolet, Oakland, and Oldsmobile operated with sufficient independence, but the coordination among these divisions was inadequate. The plans and decisions of the independent managers were poorly coordinated by the central office. The separately formulated product strategies of the units led to more competition among themselves than with Ford. Failure to coordinate on design standards also prevented the divisions from taking full advantage of the potential economies of scale when making or purchasing common components, like sparkplugs and bearings. There was also a failure to coordinate sales and production. In brief, the former organization of GM was essentially a collection of car companies and suppliers operating without any centralized coordination. The multidivisional structure GM implemented resolved these problems because, in addition to its decentralized divisions, it had a central office with a strong, professional staff to plan strategy and coordinate divisional activities. At GM, each separate division made and sold a car targeted at an

[1] The description of the U.S. cases is based on Milgrom and Roberts (1992).

assigned market segment. Each division had its own managerial team with authority to make its own operating decisions. Unlike other business organizations, GM's central office was not responsible for day-to-day operations. Its primary role was to plan and coordinate overall strategy. It was also responsible for the coordination of the research and development functions of the corporation, and hosted group meetings to share ideas about how to improve products and reduce the manufacturing costs of each division. In summary, the structure of GM was changed by the creation of an organization consisting of separate divisions well matched to a central office that coordinated business strategies. Its great success led others to mimic GM's structure and strategy.

Prior to World War I, Sears Roebuck was a highly centralized mail-order catalog business dealing in "hard goods," such as tools. After the war, it set up retail stores on the main streets of U.S. cities and expanded its product line to include "soft goods," such as clothing. Sears initially tried to maintain its centralized organization. However, consumer demands varied widely across the country, such that warm coats that would sell well in the cold northern states would not in Florida or Texas. If the organization was to respond to local conditions, managers in the different regional markets needed to be given more authority to run their local operations. Ultimately, Sears reorganized its business by establishing divisions on a regional basis, the managers of which had greater decision-making authority. As an example showing similar motivation, Niihara and Takaoka (2004) pointed out that in the Japanese franchising organizations that have appeared recently, there is an increasing tendency for the franchisees to be given more authority to develop their *own* business models and ideas, instead of just following the orders of the franchisors. In other words, though many franchising organizations still remain integrative and centralized, the process of decentralization is certainly under way.

Hoshi and Okazaki (2001) explored the historical factors in the banking industry that brought about the "Heisei bubble" and its subsequent crash. They pointed out that Japanese banks (e.g., Sumitomo and Mitsubishi) were rather decentralized in the1970s and 80s. Top managers delegated formal authority on lending to local (branch) managers. Because the incentive for promotion inside the banks was too intense, the local (branch) managers with authority competed fiercely with one another for expansion in their own market and promotion within firms as a reward. This resulted in an oversupply of liquidity, which became an important factor in the greater damage of the "Heisei bubble" and its crash.

However, there has been a recent and growing trend for big banks to integrate with one another (e.g., Sumitomo and Sakura). At the same time, since the revision of the commercial law in 1997, the firm groups, each of which consists of a holding company and business units, have often been involved in the process of merger and integration. Mizuho Financial Group in the Japanese banking industry, NTT Group in the telecommunication industry, and JFE Holdings in the steel industry are representative examples among others. The common feature is that each business unit is empowered with formal authority, and each unit decides on the optimal behavior independently having been delegated that authority, which serves to increase the unit's *initiative*. Meanwhile, the top management (professional manager) of the holding company attempts to govern Nash equilibrium behavior among the business units in the group from the viewpoint of total profit maximization. This represents the internalization of externalities by the top management (professional manager).

As an aid to understanding these phenomena, we will provide a comparative theory of non-integrated, integrated (centralized) and decentralized firms in this paper.

1.2. Literature and This Paper

Do firm boundaries affect the allocation of resources? What determines where firm boundaries are drawn? Since the landmark article "The Nature of the Firm" (1937) by Ronald Coase, these questions have already received much research attention, as mentioned below. In contrast, we know relatively little about how these boundaries affect firm behavior. Empirical evidence seems to show that integrated firms do in fact behave quite differently from non-integrated ones. Also, how the organizational structure of the firm (e.g. decentralization and authority delegation) affects firm behavior is an important problem, as historical cases show. How do we formalize this into a model?

In order to understand the essence of these phenomena, we construct a simple, concrete IO model with R&D and production activities, which is mainly based on the ideas contained in the "Firm Scope" paper by Hart and Holmstrom (2002).[2]

The existing literature on firms, based on incomplete contracts and property rights, which originated with Grossman and Hart (1986) and Hart and Moore (1990), emphasizes that the ownership of assets--- and thereby firm boundaries--- is determined in such a way as to encourage ex-ante relation-specific investments by appropriate parties. Indeed, Hart and Moore (1990) focuses on ex-ante relation-specific investments, by suppressing ex-post activities and assuming ex-post reduced form value functions. It is also generally accepted that the Grossman-Hart-Moore approach is more applicable to owner-manager firms than to large corporations.[3]

In this paper, we incorporate three important elements, in order to improve the existing modeling. First, we focus more on "ex-post decisions". They are non-contractible, but transferable through ownership. This is similar to the "ex-post decisions" view by Grossman and Hart (1986), except that they are "contractible" in Grossman and Hart (1986), while they are "non-contractible" in Hart and Holmstrom (2002) and our model. So our ex-post decisions must be modeled in a *self-enforcing* way. Second, managers enjoy private benefits that are non-transferable. The importance of this idea seems to originate with Aghion and Bolton (1992). Since this concept of "private benefits" is indeed an important element for analyzing the problem of how firm boundaries and the organizational structure of the firm (e.g., decentralization and authority delegation) affect firm behaviors, we also incorporate it into this model. Third, the decisions of managers will depend on their preferences, which in turn may depend on the scope of the firm they run. The implication of this assumption is that firm boundaries do matter: a merger between two firms will *not* be neutral, since the new manager of the integrated firm will not have, and in general cannot have, the same preferences as the two previous managers. Rotemberg and Saloner (2000) argued that managers' preferences may influence firm performance, by showing that ex ante incentives for profitable innovation may be enhanced by employing a visionary (enthusiastic) manager whose vision biases him in favor of certain projects. However, their focus was on *within-firm* bias. It also limited the model to incentive considerations and did not study such issues as decision-making or coordination, as our paper does. Our paper, like Hart and Holmstrom (2002), considers how managerial characteristic such as vision or enthusiasm can be a determinant of firm boundaries (scope).

---

[2] Our model considers the Cournot game with R &D investment, which gives good insight into the results, rather than the coordination game in Hart and Holmstrom (2002). Our model also closely and concretely examines the issue of authority delegation in the form of decentralized firm.

[3] For a critique, see Holmstrom and Roberts (1998).

By employing a concrete IO model with these ingredients, we can study the optimal scope of a firm, and the assignment of different types of managers to different types of firms and activities. First, we find that "non-integrated firms" fail to account for the external effects that their decisions have on other firms, while an "integrated firm" can internalize such externalities, but it does not take into consideration the private benefits of managers. This is a basic trade-off between the two organizational forms. Next, we consider a third model, the "Decentralized Firm", which can be viewed as an intermediate form between the "non-integration" and the "integration" regimes. The idea is that certain decisions should be put in the hands of someone with different preferences from the professional managers in order to create a balance between the internalization of externality effects and the consideration of private benefits.

We also see that our framework is closely related with the optimal delegation of formal authority in organizations. Aghion and Tirole (1997) developed a theory of the optimal allocation of formal authority (the right to decide) and real authority (effective control over decisions) within organizations. While our paper does not explicitly deal with real authority[4], it analyzes the determinants of the boundary of the firm, i.e., "Integration vs. Non-Integration". From the viewpoint of the allocation of formal authority following Aghion and Tirole (1997), "Integration" or "Centralized Firm" in our paper corresponds to a fully integrated organization, in which the professional manager has formal authority over all decisions (production and R&D). "Non-Integration" corresponds to a fully disintegrated organization, consisting of two independent units (firms) with formal authority over all decisions. However, it could cover the situation in which the local managers have formal authority over all decisions within organizations. That is, it also could be viewed as the full delegation of authority to the lower tiers of organizations. The "Decentralized Firm" is an intermediate form of the allocation of formal authority situated between "Integration" and "Non-Integration", where the professional manager determines that the R&D activities will be his own responsibility and production activities are delegated to the local managers (namely, non-delegation of authority on R&D and delegation of authority on production). We will identify some determinants of the allocation of formal authority in organizations, similar to Aghion and Tirole (1997).

Thus, we will provide a comparative theory of "Integrated", "Non-Integrated" and "Decentralized" firms. We compare the equilibrium incentives in these three second-best regimes with those in the first-best regime, i.e., the one having joint surplus maximization for two units. We then clarify in which direction a distortion arises in order to obtain the economic implications of the three regimes.

2. "Non-Integration": Regime 1

In this regime, the game is played by a pair of independent firms indexed by $i = 1, 2$. Each firm allocates resources for the production of goods and for investment in technological knowledge. The firms are assumed to have an inverse market demand function defined by;

$$p_i\left(q_i, q_j\right) = A - q_i - \beta q_j, \text{ with } |\beta| \in [0,1) \tag{1}$$

[4] Suzuki (2007) extended the collusion model of Tirole (1986) into a principal-supervisor-two agent hierarchy to revisit the notion of decentralization and delegation in firms. In doing so, he applied the formal vs. real authority argument put forward by Aghion and Tirole (1997) to understand the allocation of tasks among agents.

Each firm operates in a market which is represented by an inverse demand function relating the average price of firm *i* to its own supply q_i and the supply of firm *j* : q_j. The parameter β is an indicator of complementarity or substitutability between the production activities of the two firms. A negative β is an indicator of complementary goods, and identifies the degree of complementarity between the two firms.

Also, the firms are assumed to have cost reducing innovation with a spillover rate ϕ which is given by the following total cost formula[5];

$$c_i\left(e_i, e_j; q_i\right) = \frac{1}{e_i + \phi e_j} q_i^2, 0 \leq \phi \leq 1, \quad i = 1,2 \tag{2}$$

Each firm is facing a total cost c_i depending on the level of production activity. However, the marginal cost of production activity is negatively related to both the innovation level of the firm and the innovation of the other firm. Hence, the cost specification above implies that the cost structures of different firms producing different goods are *interdependent*. The effect of cost reducing technology on the formula above implies that, because of technological externalities, the prevailing marginal cost in a given firm (unit) depends on its own R&D as well as the R&D of the other firm, whether they are a direct competitor such as in the case of differentiated product, or a complementary firm (unit). As a consequence, R&D plays a different role here than in the case of homogeneous products since externalities might benefit the innovating firm by lowering the costs of the complement firm. Indeed, in lowering its own marginal costs, a given firm may lower the marginal cost of the other firm, with no direct negative strategic impact on the firm. The impact of innovation on the cost structure of the firm depends on the magnitude of the spillover parameter ϕ. The rate of externality ϕ measures the degree of appropriability of the innovation outcome. If ϕ is close to zero, this corresponds to situations with a high degree of R&D output appropriability, and consequently a high incentive to conduct R&D. The other polar case corresponds to situations where ϕ is close to one. This is interpreted as a low degree of appropriability and hence a low private incentive to innovate. For any intermediary value, the environment is characterized by imperfect spillovers. Thus, each firm's <u>strategy</u> consists of the pair $\sigma_i : \left(e_i, q_i\right), i = 1,2$ composed of an innovation effort and an amount of production such that $\sigma_i \in \Gamma_i$ where Γ_i denotes the strategy space of firm *i*.

Now, the <u>monetary profit</u> function R_i of firm *i* depends on the production and R&D strategies such that

$$R_i\left(\sigma_i, \sigma_j\right) = p_i q_i - \frac{1}{e_i + \phi e_j} q_i^2 - e_i \qquad i, j = 1,2 \tag{3}$$

In addition, we assume that each firm (in particular, its manager) enjoys a "<u>private benefit</u>" from its production activities in the market.[6] The benefit is non-monetary and non-transferable, such as job satisfaction and pride/self esteem generated from producing more. We for-

[5] We incorporate the cost reducing innovation/R&D activity *e* into the model, because we want to analyze the problem of "delegation of authority" as well. As the reader will see later, the production decision is delegated to the local managers in the "decentralized firm" regime, while R&D activity *e* is determined by the professional manager (e.g., the general office) with a different preference from the local managers.

[6] Recent literature incorporates this concept into models. As examples, see Aghion and Bolton (1992) and Hart and Holmstrom (2002). Also see the survey of the points of these models by Dewatripont (2001).

mulate this "private benefit" in a simple way such that

$$w_i(q_i) = w \cdot q_i, \text{ with } w \geq 0, \quad i = 1,2 \tag{4}$$

In the "Non-Integration" regime, each firm (or its manager) maximizes the sum of the monetary profit and the private benefit[7]

$$V_i = R_i + w_i = (p_i + w)q_i - \frac{1}{e_i + \phi e_j} q_i^2 - e_i \tag{5}$$

This is an important assumption.

The Nash equilibrium for this noncooperative game is a pair of Nash equilibrium strategies

$$V_i(\sigma_i^*, \sigma_j^*) \geq V_i(\sigma_i, \sigma_j^*), \forall \sigma_i \in \Gamma_i; i, j = 1,2 \tag{6}$$

Therefore, a Nash equilibrium of this innovation-production game is a pair of actions (σ_i, σ_j) such that no firm (or its manager) has an incentive to deviate from this choice taking the other firm's choice as given. The Nash equilibrium is a simultaneous maximization of the sum of the monetary profit and the private benefit for each firm. Simultaneity implies that each firm has not yet observed the other firm's R&D and production levels, when choosing its own, and therefore a firm is assumed to anticipate them correctly. Hence, the Nash equilibrium of the game must satisfy the following first order conditions,

$$\frac{\partial V_i}{\partial q_i} = \frac{\partial(R_i + w_i)}{\partial q_i} = 0, \quad i, j = 1,2 \tag{7.1}$$

and

$$\frac{\partial V_i}{\partial e_i} = \frac{\partial(R_i + w_i)}{\partial e_i} = 0, \quad i, j = 1,2 \tag{7.2}$$

which yield the reaction functions of each firm given by;

$$q_i = \frac{1}{2}\left[A + w - 2 - \beta q_j\right], \qquad i, j = 1,2 \tag{8.1}$$

and

$$e_i = \frac{A + w - 2}{\phi\beta + 2} - \frac{\beta + 2\phi}{\phi\beta + 2} e_j, \quad i, j = 1,2 \tag{8.2}$$

Under the above conditions, we have the following proposition[8];

Proposition1

(A) The unique symmetric Nash equilibrium innovation level and the corresponding unique symmetric Nash equilibrium production level are, respectively,

$$e^{NI} = \frac{A + w - 2}{(1+\phi)(2+\beta)} \text{ and } q^{NI} = \frac{A + w - 2}{2 + \beta}$$

(B) We have the comparative statics results on $e^{NI}(\phi, w, \beta)$ and $q^{NI}(w, \beta)$ as follows:

[7] Managers, who have an interest in private benefit as well as the firm's profit, are called "enthusiasts" by Hart and Holmstrom (2002).

[8] For detailed calculations, see Appendix 1.

$$\frac{\partial e^{NI}\left(\phi,w,\beta\right)}{\partial\phi}<0,\frac{\partial e^{NI}\left(\phi,w,\beta\right)}{\partial w}>0,\frac{\partial q^{NI}\left(w,\beta\right)}{\partial w}>0\text{, and}\frac{\partial e^{NI}\left(\phi,w,\beta\right)}{\partial\beta}<0.$$

Interpretation

$\partial e^{NI}\left(\phi,w,\beta\right)/\partial\phi<0$ reveals that the existence of technological externalities has a negative impact on the innovation effort of each independent firm. That is, the existence of spillovers reduces the private incentives to invest in technological knowledge, due to the free rider effect, as one firm may benefit from the innovation of the other firm.

$\partial e^{NI}\left(\phi,w,\beta\right)/\partial w>0$ and $\partial q^{NI}\left(w,\beta\right)/\partial w>0$ reveal that the existence of private benefit w has a positive impact on each firm/unit's production decision and innovation effort. This occurs because the increase of private benefit w increases the marginal benefit of increasing q_i,i = 1, 2, i.e., it makes the reaction function of i in q_i shift outward. Thus, the equilibrium quantity level q^{NI} increases with w. This increases the marginal revenue of innovation e_i for each firm/unit, and also increases the equilibrium effort level e^{NI}.

$\partial e^{NI}\left(\phi,w,\beta\right)/\partial\beta<0$ reveals that the increase (decrease) in the demand for the complementary firm increases (reduces) the innovation efforts of the firm i. In contrast, the increase in the demand for a rival firm j (i.e., a substitute firm) decreases the innovation effort of firm i. Hence, the effect on R&D innovation depends on the nature of inter-firm (unit) relationship i.e., whether the goods of the firms (units) are *complements or substitutes*.

3. "Integration"[9]: Regime 2

In this regime, the two firms are integrated with each other, and a "professional" manager, who maximizes the joint monetary profits of the two firms (units), runs the integrated firm. For simplicity, we assume that a new professional manager will be employed from outside, meaning that he/she has no linkage with the original firms 1and 2.
Then, the assumption that the new professional manager maximizes just the joint monetary profits of the two firms (units) will be justified.[10] The important point is that the new manager does not consider the "private benefits" of the two original firm managers.[11] In this game, the new professional manager decides the joint R&D effort level and separate production levels that maximize the joint monetary profit as a function of q_i , q_j and e. The financing of the R&D is borne by the two divisions (units) according to a prior sharing rule $\left(1/2,1/2\right)$.
Therefore, $e_i=\left(1/2\right)e$, $i=1,2$.We assume that the professional manager decides a total R&D level e and orders the execution of half of e to each unit. We also avoid the problem of *enforceability*, i.e., each unit just follows the order to execute $\left(1/2\right)e$.[12] This corresponds to the

[9] "Integration" corresponds to "Centralization" or the "Centralized Firm" in the anecdotes in the introduction.

[10] If the manager of firm 1 becomes the new manager of the integrated firm, he/she will maximize the joint monetary profits R^I plus his/her private benefit $w_1\left(q_1\right)=wq_1$, i.e., $R^I+w_1=R_1+R_2+w_1$.

[11] Hence, this is not merely a "cooperative game" between the two firms, in the game theoretical sense. Similarly, even if the integration under an enthusiastic manager (e.g. the firm 1 manager) is allowed, the first best (defined more precisely in Section 5) cannot be achieved by itself.

[12] A typical enforcement mechanism for the professional manager's formal authority to really work would be the repetition of the relation between the parties after integration.

situation, where, in centralized organizations, top management and its staff can control the operating decisions of their units (divisions) directly.[13]

The equilibrium for this game is a triplet $\left(e, q_i, q_j\right)$ chosen in such a way that the "professional manager" maximizes the joint monetary profit. The joint monetary profit function is defined according to the following;

$$R^I\left(e, q_i, q_j\right) = R_i\left(e, q_i\right) + R_j\left(e, q_j\right) \tag{9}$$

which is equivalent to:

$$R^I\left(e, q_i, q_j\right) = \sum p_i q_i - \sum \frac{1}{e_i + \phi e_j} q_i^2 - \sum e_i \tag{10}$$

and hence

$$R^I\left(e, q_i, q_j\right) = \sum p_i q_i - \sum \frac{1}{(1/2)(1+\phi)e} q_i^2 - e \tag{10'}$$

The first order conditions of the joint monetary profit maximization are given by the following system of equations;

$$\frac{\partial R^I\left(e, q_i, q_j\right)}{\partial q_i} = 0, \quad i, j = 1, 2 \tag{11.1}$$

and

$$\frac{\partial R^I\left(e, q_i, q_j\right)}{\partial e} = 0 \tag{11.2}$$

which yields the following proposition[14];

Proposition2

(A) The cooperative R&D effort and the corresponding aggregate production level are, respectively,

$$e^I = \frac{1}{(1+\beta)\sqrt{1+\phi}}\left[A - \frac{2}{\sqrt{1+\phi}}\right] \quad \text{and} \quad q^I = q_1{}^I + q_2{}^I = \frac{1}{(1+\beta)}\left[A - \frac{2}{\sqrt{1+\phi}}\right]$$

(B) Comparison between "Non-Integration" and "Integration"; when $\beta \geq 0$, i.e., there exists a competing relationship (substitutability) between the two units, as the degree of private benefit w becomes greater, and as the spillover rate (the degree of externality) ϕ becomes smaller, q^{NI} tends to be greater than $\overline{q}^I$ (the average production level under "Integration")

Proof

$$q^{NI} = \frac{A + w - 2}{2+\beta} \geq \frac{1}{2(1+\beta)}\left[A - \frac{2}{\sqrt{1+\phi}}\right] = \overline{q}^I \Leftrightarrow \frac{2(1+\beta)}{2+\beta}\frac{[A + w - 2]}{\left[A - 2/\sqrt{1+\phi}\right]} \geq 1$$

When $\beta \geq 0$, a sufficient condition for the above condition is $w \geq 2\left(1 - 1/\sqrt{1+\phi}\right)$.

---

[13] It is notable that Samsung Electronics in Korea has a "top-down" decision-making structure by the leader (owner-manager) and its staff.

[14] For detailed calculations, see Appendix 2.

As can be seen, when the degree of private benefit w becomes greater, and as the spillover rate (the degree of externality) ϕ becomes smaller, this inequality tends to be satisfied. That is, q^{NI} tends to be greater than $\overline{q}^{I}$. This reflects the basic trade-off that lies between "Non-Integration (consideration of w and ignoring of ϕ) and Integration (ignoring w and internalization of ϕ)"

4. "Decentralized Firm"[15]: Regime 3

The basic trade-off so far is as follows. In the "Non-Integration" regime, the managers of the two independent firms do not consider the positive externalities of their R&D efforts, and thus this will generally lead to underinvestment in R&D, though the 'private benefit' effect wq mitigates this underinvestment effect to some degree. On the other hand, in the "Integration" regime, a "professional manager" maximizes the sum of the monetary profits, ignoring "private benefits", such as job satisfaction and pride/self esteem of the local managers. This reduces the joint total surplus. Therefore, there exists a trade-off between the internalization of externalities and the loss of the private benefits in the comparison of two regimes presented so far. Therefore, a third model will now be considered. This is the "Decentralized Firm", which can be viewed as an intermediate form between the "Non-Integration" and "Integration" regimes.

As stated by Milgrom and Roberts (1992), historically speaking, the multidivisional firm ("Decentralized Firm" in our model) emerged in an era when there were only two major alternatives: highly centralized organizations (in our model, "Integrated" firms), such as that which had previously existed at Sears and DuPont, and organizations with almost no control (i.e., a "too decentralized" form, represented in our model, by "Non-Integrated" firms), such as the form that existed at GM before the reforms undertaken by Alfred Sloan. The rationale for the multi-divisional structure ("Decentralized Firm") in GM was to carry out Sloan's new market-segmentation strategy, which also fits our "two market" model. GM then placed product and marketing decisions in the hands of divisional managers, i.e., formal authority was delegated to the lower levels of the organization.

Based on this evidence, we hypothesize that in the "Decentralized Firm" regime, a professional manager chooses an R&D effort level with the objective of maximizing the joint monetary profits[16], while the local managers of the two units (divisions) maximize the sum of their unit's monetary profit and their own "private benefit", independently and simultaneously. They are delegated the formal authority of choosing the production activities. Hence, we can say that the "Decentralized Firm" is an intermediate allocation form of formal authority, in that the formal authority on the R&D decision is centralized and the formal authority on the production decision is (divided and) delegated to the local managers (the lower levels of the organization).

Now, let us show how the model works.[17] First, each of the local managers of the two

[15] The "Decentralized Firm" regime corresponds to the "M-form structure" as described by Williamson (1985) or the "Multidivisional form" (Milgrom and Roberts (1992)), though we do not deal with the "information asymmetry" and "internal capital market "arguments as their models do. Suzuki (2002) examined such problems in a principal-supervisor-two agent hierarchy. This paper is more interested in the optimal scope of a firm i.e., the determination of "firm boundary" through the trade-off between the internalization of externalities and the consideration of "private benefit".

[16] This may be said to reflect the idea by Williamson (1985, p. 283) that the "M-form structure" removes the general office executives, i.e., the professional manager in our model, from *partisan involvement* in the functional parts and assigns operating responsibilities to the divisions, and that the general staff, moreover, is supported by an elite staff, independent of the divisional interests.

units chooses the production level q_i in order to maximize the sum of his/her monetary profit and his/her private benefit, given that the "professional manager" decides the common R&D level e. So, manager i maximizes with respect to q_i , given e and q_i ;

$$V_i^{DF} = R_i^{DF} + w_i = \left(p_i + w\right)q_i - \frac{1}{(1/2)(1+\phi)e}q_i^2 - \frac{1}{2}e, \quad i, j = 1,2 \tag{12}$$

That is, the following first order conditions must be satisfied.

$$\frac{\partial V_i^{DF}}{\partial q_i} = \frac{\partial\left(R_i^{DF} + w_i\right)}{\partial q_i} = 0, \quad i, j = 1,2 \tag{13}$$

which is equivalent to these set of equations

$$\left(A + w - q_i - \beta q_j\right) - q_i - \frac{2}{(1/2)(1+\phi)e}q_i = 0, \quad i = 1,2 \tag{14}$$

We restrict our attention to the symmetric equilibrium $q_i = q_j = q^{DF}$, and thus we have;

$$A + w - (1+\beta)q^{DF} - q^{DF} - \frac{2}{(1/2)(1+\phi)e}q^{DF} = 0 \Leftrightarrow A + w = \left[(2+\beta) + \frac{4}{(1+\phi)e}\right]q^{DF} \tag{15}$$

From the simple calculation, we have;

$$\frac{dq^{DF}}{de} = \frac{4}{(1+\phi)}\left(\frac{q^{DF}}{e}\right)^2 > 0, \text{ and } \frac{d^2 q^{DF}}{de^2} = \frac{-4\left(q^{DF}\right)^2}{(1+\phi)}\frac{1}{e^4} < 0$$

This shows that an increase in the professional manager's effort e unanimously induces the local managers to produce more q in equilibrium. That is, the local managers' best response curve against the professional manager's effort e is *upward sloping* (in contrast to the model of Aghion and Tirole (1997)).

Next, the "professional manager" maximizes the joint monetary profit with respect to e , given that the two local managers choose the symmetric Nash equilibrium production level q^{DF}. Hence, the professional manager's objective is to maximize with respect to e given q^{DF}

$$R^I\left(e, q^{DF}\right) = R_i\left(e, q^{DF}\right) + R_j\left(e, q^{DF}\right) = \sum p_i \cdot q^{DF} - \frac{2}{(1/2)(1+\phi)e}\left(q^{DF}\right)^2 - e \tag{16}$$

The first order condition is;

$$\frac{2}{(1/2)(1+\phi)e^2}\left(q^{DF}\right)^2 = 1 \tag{17}$$

The only economically admissible root is;

[17] Carmichael (1983) considered a model, where the principal also makes a common productive effort and the two agents compete with each other under tournament or relative performance evaluation. Their efforts are chosen in a self-enforcing way. It is somewhat similar to our model in its structure and solution, but does not consider the problems of "firm boundary" and "delegation of authority".

$$q^{DF} = \frac{\sqrt{1+\phi}}{2} e \iff e = \frac{2}{\sqrt{1+\phi}} q^{DF} \tag{18}$$

This shows that the professional manager also increases her effort e for strategic reasons, so that the professional manager's best response curve is also *upward sloping*. This corresponds to a situation of *strategic complementarity*.

From (15) and (18), we have the equilibrium production and R&D levels.

<u>Proposition 3</u>

(A) The symmetric Nash equilibrium production level and the corresponding Nash equilibrium R&D effort are, respectively,

$$q^{DF} = \frac{1}{2+\beta}\left[A + w - \frac{2}{\sqrt{1+\phi}}\right] \text{ and } e^{DF} = \frac{2}{\sqrt{1+\phi}} q^{DF} = \frac{2}{\sqrt{1+\phi}} \cdot \frac{1}{2+\beta}\left[A + w - \frac{2}{\sqrt{1+\phi}}\right]$$

(B) We have that, for all $0 \le \phi \le 1$, $w \ge 0$

$$q^{DF} = \frac{1}{2+\beta}\left[A + w - \frac{2}{\sqrt{1+\phi}}\right] \ge \frac{1}{2+\beta}\left[A + w - 2\right] = q^{NI} \tag{19}$$

and

$$e^{DF} = \frac{2}{\sqrt{1+\phi}} q^{DF} \ge \frac{1}{1+\phi} q^{NI} = e^{NI} \tag{20}$$

The "Decentralized Firm" <u>internalizes the externality effect</u> of R&D innovation, and so under the lower production cost, generates the incentive to produce more, due to the <u>private benefits</u>. Hence, we can say that the "Decentralized Firm" manages the trade-off between externality and private benefits more successfully than "Non-Integration" does.

(C) Comparison between the "Decentralized Firm" and "Integration"; the condition for $q^{DF} \ge \overline{q}^{I}$ is as follows.

$$q^{DF} = \frac{1}{2+\beta}\left[A + w - \frac{2}{\sqrt{1+\phi}}\right] \ge \frac{1}{2(1+\beta)}\left[A - \frac{2}{\sqrt{1+\phi}}\right] = \overline{q}^{I} \iff w \ge \frac{-\beta}{2(1+\beta)}\left[A - \frac{2}{\sqrt{1+\phi}}\right]$$

(C.1) when $\beta \ge 0$, i.e., there exists a competing relationship (<u>substitutability</u>) between the two units, we always have $q^{DF} \ge \overline{q}^{I}$.

(C.2) when $\beta \le 0$, i.e., when there exists a <u>complementary</u> relation between the two units, as the amount of private benefit w becomes greater, and as the spillover rate (the degree of externality) ϕ becomes smaller, this inequality tends to be satisfied. In contrast, as w becomes smaller, and as the degree of complementarity $|\beta|$ becomes greater, the incentive to expand production becomes greater through the internalization of *positive externalities* of q under "Integration".

<u>Remark</u> Another way of delegating authority in the "Decentralized firm"

There are two decisions (R&D and production) in our model and each one can be made by one manager or two. This leads to three leading organizational forms. That is, "Integration", "Non-Integration", and "Decentralized firms". We have already studied the former two organizational forms. In a decentralized firm, one decision is made at headquarters and the other by local bosses (managers). In the decentralized firm analyzed so far, the R&D decision e is in the hands of one global boss (professional manager) at headquarters, while the production decisions q_i are in the hands of two local bosses (managers) $i = 1, 2$. Now, there is another form of decentralized firm, where the roles of the R&D decision and the production decisions are reversed. That is, the production decisions are in the hands of one global boss (professional manager), while the R&D decisions are in the hands of two local bosses (managers). In this case, under our assumption that there are no private benefits from the R&D activities, the R&D activities will be underprovided in equilibrium, i.e., "too little coordination", while the production decisions are internalized by the global boss (professional manager). By a similar simple calculation, we see that equilibrium R&D and production levels are both smaller than those in "Integration" or "Centralized firm". Thus we can identify that the delegation form we considered in Section 4 is not only the "natural", but also the "optimal" way to delegate authority in the "Decentralized firm".

5. "Joint Surplus Maximization" Regime

In this section, we analyze the "Joint Surplus Maximization" regime, which is the first-best optimum regime for the two units. This is a "bench mark" regime, since no manager exists whose preference is to maximize the joint surplus of the two units. The manager of each unit, if he/she becomes a top manager, will maximize the joint monetary profits R^I plus his/her private benefit $w_1(q_1) = wq_1$, i.e., $R^I + w_1$. The professional manager, who is employed from outside and has no linkage with the original units, will maximize only the joint monetary prof its R^I. Thus, no manager exists, whose 'vision' is to maximize the joint surplus of the two units. That is why the "Joint Surplus Maximization" cannot be implemented in equilibrium.

The joint surplus function is expressed as the total sum of the monetary profit and the private benefit, and is given by $\Pi^{JS} = R^I(e, q_i, q_j) + w_i(q_i) + w_j(q_j)$, which is equivalent to the following equation;

$$\Pi^{JS} = R_i(e, q_i) + R_j(e, q_j) + w \cdot (q_i + q_j) = \sum (p_i + w) q_i - \sum \frac{1}{(1/2)(1+\phi)e} q_i^2 - e$$

The first order conditions of the joint surplus maximization are given by;

$$\frac{\partial \Pi^{JS}(e, q_i, q_j)}{\partial q_i} = 0, \quad i, j = 1, 2$$

and

$$\frac{\partial \Pi^{JS}(e, q_i, q_j)}{\partial e} = 0$$

So we have the following results[18].

The "first best" R&D innovation effort and the corresponding aggregate production level are, respectively,

[18] For detailed calculations, see Appendix 3.

$$e^{JS} = \frac{1}{(1+\beta)\sqrt{1+\phi}}\left[A+w-\frac{2}{\sqrt{1+\phi}}\right] \text{ and } q^{JS} = \frac{1}{(1+\beta)}\left[A+w-\frac{2}{\sqrt{1+\phi}}\right]$$

6. Summary of the Results and Implications

Now, let us summarize the equilibrium outcome under each regime analyzed so far. From Table 1, we can find the three cases where there is *no trade-off* between externalities and private benefits, or the trade-off can be solved perfectly. These are important from the viewpoint of the comparison of organizational forms.

	Production q	R&D innovation e
Non-Integration	$q^{NI} = \frac{A+w-2}{2+\beta}$	$e^{NI} = \frac{A+w-2}{(1+\phi)(2+\beta)}$
Integration	$\bar{q}^{I} = \frac{1}{2(1+\beta)}\left[A-\frac{2}{\sqrt{1+\phi}}\right]$	$e^{I} = \frac{1}{(1+\beta)\sqrt{1+\phi}}\left[A-\frac{2}{\sqrt{1+\phi}}\right]$
Decentralized Firm	$q^{DF} = \frac{1}{2+\beta}\left[A+w-\frac{2}{\sqrt{1+\phi}}\right]$	$e^{DF} = \frac{2}{(2+\beta)\sqrt{1+\phi}}\left[A+w-\frac{2}{\sqrt{1+\phi}}\right]$
First Best	$q^{JS} = \frac{1}{2(1+\beta)}\left[A+w-\frac{2}{\sqrt{1+\phi}}\right]$	$e^{JS} = \frac{1}{(1+\beta)\sqrt{1+\phi}}\left[A+w-\frac{2}{\sqrt{1+\phi}}\right]$

Table 1

<u>Proposition4.1</u>

(A) When $\phi=\beta=0$ and $w \geq 0$, "Non-integration" with the two firms independent can attain the joint surplus maximization and is thus first-best optimal.

(B) When $w = 0$ and $\phi \in (0,1], |\beta| > 0$, "Integration" can attain the joint surplus maximization and is thus first-best optimal.

(C) When $\beta = 0$ and $\phi \in (0,1], w > 0$, "Decentralized Firm" can attain the joint surplus maximization and is thus first-best optimal.

<u>Proof</u>

(A) When $\phi=\beta=0$ and $w \geq 0$, we have from Table 1,

$$q^{NI} = q^{JS} = (A+w-2)/2 \text{ and } 2e^{NI} = 2\times(A+w-2)/2 = A+w-2 = e^{JS}$$

<u>Rationale</u> $\phi=\beta=0$ means that there are no externalities, since the two units are *fully independent* and *separable*. Hence, there is no problem in not taking into consideration the internalization of externalities. Then, it is natural that Non-integration is optimal.[19]

[19] Though "Decentralized Firm" similarly attains the first best, it is essentially the same as Non-integration, and so was omitted.

(B) When $w = 0$ and $\phi \in (0,1], |\beta| > 0$, we have from Table 1,

$$\bar{q}^{I} = q^{JS} = \frac{1}{2(1+\beta)}\left[A - \frac{2}{\sqrt{1+\phi}}\right] \text{ and } e^{I} = e^{JS} = \frac{1}{(1+\beta)\sqrt{1+\phi}}\left[A - \frac{2}{\sqrt{1+\phi}}\right]$$

Rationale $w = 0$ means that there are no private benefits. Hence, there is no problem associated with ignoring the private benefits. Then, it is natural that Integration (Centralization) is optimal.

(C) When $\beta = 0$ and $\phi \in (0,1], w > 0$, we have from Table 1,

$$q^{DF} = q^{JS} = \frac{1}{2}\left[A + w - \frac{2}{\sqrt{1+\phi}}\right] \text{ and } e^{DF} = e^{JS} = \frac{1}{\sqrt{1+\phi}}\left[A + w - \frac{2}{\sqrt{1+\phi}}\right]$$

Rationale The professional manager has no concern for private benefits w, and the local (divisional) managers have no concern for internalization of externalities brought about by their activities. Now, $\beta = 0$ means that there are no externalities about the market demands. Then, it is optimal to allocate control over cost reducing activities to the professional manager who internalizes their externalities and production activities $q_i, i = 1, 2$ to the local (divisional) managers who take into consideration their private benefits w. Intuitively, dividing control disciplines the professional manager when choosing e, since a higher e induces the local (divisional) managers to increase $q_i, i = 1, 2$ in order to increase their payoffs, which in turn increases the marginal incentive of the cost reducing activity. This result is interesting, because it implies the optimality of *dividing authority* between the two parties with regard to *complementary activities*, instead giving full control to either of the two.

Next, we examine the cases where the first-best is basically impossible, due to the trade-off between externalities ϕ, β and private benefits w. We have the following proposition on the comparison of equilibrium incentives.

Proposition4.2

(A) The comparison of equilibrium production activities between the three regimes depends on the production structure as captured by the complementarity (substitutability) parameters β, the size of the private benefit w, and the magnitude of spillovers ϕ. If $\beta \geq 0$ (substitutable goods) and $w \geq 2\left(1 - 1/\sqrt{1+\phi}\right)$, i.e., when the private benefit w is relatively greater, then we have $q^{DF} \geq q^{NI} \geq \bar{q}^{I}$. We also have $q^{NI} \leq q^{DF} \leq \bar{q}^{I}$, if and only if $\beta \leq 0$ (complementary goods) and $0 \leq w \leq -\beta\left[A - 2/\sqrt{1+\phi}\right]/2(1+\beta)$.

(B) We have the results on the comparison of equilibrium R&D innovation between three regimes. If $\beta > 0$ (substitutable goods), R&D innovation e is greater in "Decentralized Firm" than in "Integration" for all $0 \leq \phi \leq 1$, $w \geq 0$, i.e.,$e^{DF} > e^{I}$. However, if $\beta < 0$ (complementary goods), it critically depends on the relative size of the degree of complementarity β and the size of the private benefit w. As w becomes relatively greater, e^{DF} tends to be greater than e^{I}. In which regime of "Non-Integration" and "Integration" R&D innovation e is greater depends on the trade-off between the internalization of externality (the rate of spillover) ϕ and the size of the private benefit w. As w (ϕ) becomes relatively greater, e^{NI} (e^{I}) tends to be greater.

(C) "Integration" brings about under-production and under-innovation results, due to the fact that no consideration is given to the private benefit w. That is, $\overline{q}^{I} \leq q^{JS}$ and $e^{I} \leq e^{JS}$ for $w \geq 0$ and $0 \leq \phi \leq 1$. As for the comparison on incentives between the "Decentralized Firm" and the First Best, if $\beta \geq 0$ (substitutable goods), then we have $q^{DF} \geq q^{JS}$ and $e^{DF} \geq e^{JS}$, which we can call the over-production and over-innovation results, and vice versa.

(D) As ϕ goes to 0, q^{NI} tends to be greater than q^{JS} for $\beta > 0$. As β (>0) goes to 0, q^{JS} tends to be greater than q^{NI} for $0 \leq \phi \leq 1$. Suppose $\phi = 0$ (or small enough). If $\beta > 0$ and $w = 0$, we have $q^{NI} > q^{JS} > q^{I}$.

Proof See Appendix 4.

6.1. Implication for Competition Policy: Consumer Beneficial Organization Structure

We consider the implication for competitive policy, focusing on proposition 4.2 (A). The question is which organizational structure is the most beneficial for consumers.

Case 1: $q^{DF} \geq q^{NI} \geq \overline{q}^{I}$ under the condition that $\beta \geq 0$ and $w \geq 2\left(1 - 1\big/\sqrt{1+\phi}\right)$ corresponds to the situation where the "decentralized firm" brings about the greatest expansion of production between the three organizational forms, through the negative externality of production q for $\beta \geq 0$ (substitutable goods) and the production expansion brought about by the relatively large private benefit w. In this case, the market prices are ranked as $p^{DF} \leq p^{NI} \leq p^{I}$ in equilibrium. Hence, the "decentralized firm" is the most beneficial for consumers.

Case2: $q^{NI} \leq q^{DF} \leq \overline{q}^{I}$ with $\beta \leq 0$ and $0 \leq w \leq -\beta\left[A - 2\big/\sqrt{1+\phi}\right]\big/2\left(1+\beta\right)$ corresponds to the case where the effect of the internalization of the externalities under the "Integration" regime is largest. In this case, production expands mainly through both the large reduction in marginal costs (the internalization of the positive externality of cost reducing activity e) and the internalization of the positive externality of production q for $\beta \leq 0$. The market prices are ranked as $p^{I} \leq p^{DF} \leq p^{NI}$ in equilibrium. Hence, "Integration" is the most beneficial for consumers.[20]

An Interpretation: Why banks moved towards decentralization in the 1970s and 1980s, and towards centralization in the 1990s

In some Japanese banks, top managers delegated authority to local managers in the 1970s and 1980s.[21] The market condition was $\beta > 0$, i.e., substitutable goods and services, and the size of private benefits w accompanying the market expansion seems to have been relatively great, in part because the incentive for promotion inside the banks was intense. Under such

[20] This is the same as the multi-product monopoly model with complementary goods, except for the private benefits . As Tirole (1988) explains, an increase in the production of good i raises the demand for good j, and so the professional manager (top management) will sell enough of a good, so as to sufficiently raise the demand for another good. This leads to the lowest market price P^{I} under "Integration".

[21] See Hoshi and Okazaki (2001).

conditions, the local managers with authority competed with one aother for expansion in their own market. Hence, the two main forces that $\beta > 0$ and w was large drove organizations towards decentralization, which was beneficial also from the viewpoint of consumers (borrowing firms).

During the 1990s, due to the development of information technology, information sharing became less costly (easier), i.e., ϕ became greater. In addition, the size of private benefits w became relatively smaller, in part because some of the source for private benefits (e.g., job satisfaction and pride) disappeared under the blockage due to the collapse of the bubble economy in the 1990s and the subsequent decline of the Japanese economy. In this situation, the two units tried to integrate with each other, and improve joint profit by internalizing the negative externalities brought by the substitutable services, i.e., $\beta > 0$. Hence, the forces that made ϕ greater, w smaller, and $\beta > 0$ drove organizations towards centralization ("Integration"). In this case, the two units were competitors because of the substitutability of their services. However, through integration, they were given incentives to raise their own prices (credit interests), thereby eliminating the negative externalities between them. This might explain the recent tendency of big banks to merge (e.g., Sumitomo and Sakura). A notable point is that this "integration" is beneficial not for consumers (borrowing firms), but from the point of view of the aggregate firm (integrated firm). Indeed, the consumers (borrowing firms) that had fallen into bankruptcy increased in number during the decade.

6.2. "Zero-Sum" Private Benefit Function: $w_1(q_1) + w_2(q_2) = 0$

If we assume that the private benefit functions have a "zero-sum" structure, i.e., $w_1(q_1) + w_2(q_2) = 0$, the joint surplus maximization is equivalent to the joint monetary profits maximization. This is achieved in the "Integration", i.e., "Centralization" regime. Hence, the "Integration" regime is the (first-best) optimal, and we point out the following.

Corollary

If the private benefits are distributed *unequally*, such as in the "Zero-Sum" structure, $w_1(q_1) + w_2(q_2) = 0$, "Integration" or "Centralization" is optimal.

6.3. The Possibility of *Enforceable* Contract between Two Local (Divisional) Managers in a Decentralized Firm.

Suppose that an *enforceable* contract is possible between two local (divisional) managers in a Decentralized firm. We have the following proposition.

Proposition5

If an *enforceable* contract is possible between two local (divisional) managers, it is optimal to delegate the authorities of production activities to them, thereby letting them choose production activities *cooperatively*, expecting the professional manager's choice of R&D effort.

The proof is relegated to Appendix 5. The argument is as follows. Given that the professional manager chooses R&D activity e, two local (divisional) managers cooperatively choose production activities $q_i, i = 1, 2$ so as to maximize their joint surplus. Similarly, given the two local (divisional) managers' cooperative behavior, the professional manager chooses R&D activity e so as to maximize the monetary total profit. Then, production activities $q_i, i = 1, 2$

and R&D activity e are chosen so as to fully internalize externalities by the union of two local managers and the professional manager, respectively. Hence, the first best allocation is achieved in a Nash equilibrium of a non-cooperative game between the union of two local managers and the professional manager.

This is an interesting theoretical remark, but, since any *enforceable* contract is impossible between two local (divisional) managers and actions must be chosen in a *self-enforcing* way, this solution is impossible.

7. Two Remarks on the Analysis of the Paper

Thus far we have emphasized the interpretation where the private benefits w_i are enjoyed by a single manager in each unit, who is the boss under non-integration and a subordinate under integration. The interpretation that private benefits are enjoyed by a single manager is restrictive in that it implies that the units are in effect sole proprietorships under non-integration. However, there is a second interpretation of the model, and it is worth mentioning the interpretation that applies to the case where the units are large companies. We can imagine that the private benefits refer to the job satisfaction of unit i workers rather than the private benefits of a single manager, and that some bosses have goals that are (partially) congruent with those of the workers, i.e., they care about the same things. In particular, suppose that there are three types of bosses, a unit 1 enthusiast with preference $m + \lambda_1 w_1$, a unit 2 enthusiast with preference $m + \lambda_2 w_2$, and a professional manager with preference m, where m is money and λ_1, λ_2 represent congruence between a boss's goals and those of unit 1 and 2 workers. In our model's terminology, a unit i enthusiast will maximize $R_i + \lambda_i w_i$, while a professional manager will maximize $R = R_1 + R_2$. Monetary profit can be diverted by the bosses. Then, if we make the simplifying assumption that $\lambda_1 = \lambda_2 = 1$, this yields the same objective functions for the different kinds of bosses as the model without workers analyzed so far.

In this interpretation, the choice of organizational form is made by the initial owners of units 1 and 2 at the beginning of the period. They must decide whether the units should be separate (non-integration), together (integration) or its intermediate form (delegation or the decentralized firm), and what kind of boss to be placed in charge. Assume that owners face a competitive labor market and wages are agreed upon up front. Then, the total wage ω_i for unit i workers will satisfy $\omega_i + w_i = U$, where U is the (total) market clearing reservation wage (a constant), and w_i refers to (expected) worker private benefits. Suppose that the initial owners wish to sell and retire, i.e., they are interested only in money. Then, given that side-payments are possible, organizational form will be selected by the owners to maximize the total value of the two units, net of the wages. From the above argument, maximizing total profits net of worker wages is equivalent to maximizing total profits plus worker private benefits, i.e. $R_1 + R_2 + w_1 + w_2 \left(= V_1 + V_2\right)$. Thus, we can justify having the private benefits $w_i, i = 1, 2$ included in the welfare calculations that are used to determine which of three organizational forms is most efficient and can attain the most efficient corporate governance.

The conclusion is that the parties will choose an organizational form at date 0 that maximizes net total surplus, subject to the equilibrium behavior of the managers (bosses), and that our formulation and analysis is consistent with the standard assumption by economists that owners are optimizing the organizational structure.

The second remark is on incentive schemes. Fortunately, another feature of $\lambda_i = 1, i = 1, 2$ is that it can avoid the need to consider incentive schemes. Clearly there is no role for an incentive scheme based on unit *i* profit, in the case of a unit *i* enthusiast (narrow boss), since such a boss has the "right" preferences for his/her unit (total profit plus worker private benefits, i.e., total surplus). An incentive scheme only makes things worse in the case of a professional manager, since he/she already cares too much about profit.

It might be desirable to reward unit *i* 's boss according to unit *j* 's profits in order to encourage coordination. Note, however, that this will not "solve" the coordination problem unless unit *j* 's workers' private benefits can also be made part of this incentive scheme (which is impossible, because these benefits are not verifiable). Anyway, it is an important point that our argument essentially assumes a world with incomplete contracts.

8. Conclusion

In this paper, a two-unit model of production and R&D innovation is presented. The model presented is similar to the traditional view of the firm as a technologically defined entity that makes decisions about inputs, outputs, and investments. Holmstrom and Roberts (1998) pointed out the importance of viewing a firm as an entity of "units and activities", as well as considering "asset ownership": the core of the property right theory as defined by Grossman-Hart-Moore.

Based on the idea of Hart and Holmstrom (2002), which formalizes the view of the firm as an entity of "units and activities", but by employing a concrete IO setting (Cournot game with R &D investment, different from the coordination game in Hart and Holmstrom (2002)), we studied the optimal scope of a firm, and the assignment of different types of managers to different types of firms and activities.[22] We find that non-integrated firms fail to account for the external effects that managers' decisions (R&D and production decisions) have on other units. An integrated firm can internalize such externalities, but it does not take into consideration the private benefits of the local managers. So, in order to create a balance between the internalization of externality effects and the consideration of the private benefits, we consider a third model, the "Decentralized Firm", which is an intermediate form between the "Non-Integration" and "Integration" regimes. It means that production decisions are put in the hands of the local managers, who have different preferences from the professional manager, who takes charge of R&D decision-making.

From the viewpoint of the allocation of formal authority in the manner described by Aghion and Tirole (1997), "Non-Integration" corresponds to a fully disintegrated organization, consisting of two independent units (firms) with formal authority over all decisions (production and R&D), though it can also cover the situation where each of the local managers has formal authority over all decisions (production and R&D) within firms. "Integration" or "Centralized Firm" corresponds to a fully integrated organization, in which the professional manager has formal authority over all decisions (production and R&D). The "Decentralized Firm" is an intermediate form of allocation of formal authority situated between "Integration" and "Non-Integration", where the professional manager determines that R&D activities will be his own responsibility and production activities are delegated to the local managers (namely, non-delegation of formal authority on R&D and delegation of formal authority on production). We attempted to identify some determinants of the optimal allocation of formal authori-

[22] Our model could give good insight into the results, rather than Hart and Holmstrom (2002).We also closely and concretely examined the issue of authority delegation in the form of Decentralized firm.

ty, similar to Aghion and Tirole (1997).

We compared these three regimes (organizational forms or allocation forms of formal authority) mainly from the viewpoint of “marginal incentives”, and obtained some interesting economic implications. Thus, we provided a comparative theory of “Integrated”, “Non-Integrated” and “Decentralized” firms.

Acknowledgements

This paper was begun when the author was a visiting scholar at Harvard University from April 2002 to March 2003. He is grateful to the university for its stimulating environment and the hospitality. He also thanks the seminar participants at Hosei University, Kyoto University, and *Econometric Society* Far Eastern Meeting, Beijing, 2006 for their valuable comments. This work was supported by the Grant-in-Aid for Scientific Research (c) by the Japan Society for the Promotion of Science (No. 17530192 (2005-2006) and No. 20530162 (2008-2010)).

REFERENCES

Aghion, P and P. Bolton (1992) “An Incomplete Contracts Approach to Financial Contracting”. *Review of Economic Studies*. 59. 473 – 494

Aghion, P and J.Tirole. (1997) “Formal and Real Authority in Organizations”. *Journal of Political Economy*. Vol. 105 No 1.1-29.

Carmichael. L (1983) “The Agent-Agents Problem: Payments by Relative Outputs”, *Journal of Labor Economics* 1: 50-65.

Dewatripont, M. (2001), “Authority,” Walras-Bowley Lecture at *Econometric Society*

Grossman, S and O.Hart (1986), “The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration”, *Journal of Political Economy*, 94,691-719.

Hart, O. and B.Holmstrom (2002) “A Theory of Firm Scope” mimeo, Harvard and MIT.

Hart, O. and J.Moore (1990) “Property Rights and the Nature of the Firm”, *Journal of Political Economy*, 98, 1119-1158.

Holmstrom, B and J. Roberts (1998) “The Boundaries of the Firm Revisited”, *Journal of Economic Perspectives*, Vol.12, No 4, Fall, 73-94.

Hoshi, T and T.Okazaki (2001) “1980 nendai-no Ginko Keiei –Senryaku, Sosiki, Gabanansu (Management of Banks in 1980s: Strategy, Organization, and Governance)” in *Heisei Baburu no kenkyu (zyou) (A Study of the Heisei Bubble, Part1)* Muramatsu and Okuno eds. Toyokeizai-shimpousya (in Japanese)

Milgrom, P and J.Roberts. (1992) *Economics, Organization and Management*, Prentice-Hall, Englewood Cliffs.

Niihara, H and M.Takaoka (2004) “Franchise Soshiki no Bunkenteki Shinka to Tagenka,” (Evolution of Decentralization in Franchising Organizations and Their Multiplicity) *Soshiki Kagaku* (The Organizational Science), Vol.38, No.1, 4-15. (in Japanese)

Rotemberg, J. and G. Saloner (2000), “Visionaries, Managers, and Strategic Direction”, *RAND Journal of Economics*, Vol. 31, No. 4, 693-716.

Suzuki, Y (2007) "Collusion in Organizations and Management of Conflicts through Job Design and Authority Delegation ", *Journal of Economic Research* Vol.12.203-241 (2007)

Tirole, J. (1986) “Hierarchies and Bureaucracies: On the role of Collusion in Organizations". *Journal of*

Law, Economics and Organization. 2. 181-214.
Tirole, J (1988) *Theory of industrial* Organization. Cambridge, MA: M.I.T Press.
Williamson, O. (1985), *Economic Institutions of Capitalism*, New York, Free Press.

APPENDICES

Appendix 1 Derivation of the Equilibrium Outcome of the "Non-Integration' Regime

In the "Non-Integration" regime, each firm (its manager) maximizes the sum of the monetary profit and the private benefit. It depends on the output strategies and the innovation strategies of each firm (manager);

$$V_i = R_i + w_i = \left(p_i + w\right) q_i - \frac{1}{e_i + \phi e_j} q_i^2 - e_i, \qquad i = 1,2 \tag{1}$$

Substituting the inverse market demand of firm *i* into equation (1), we have;

$$\begin{aligned} R_i + w_i &= \left(p_i + w\right) q_i - \frac{1}{e_i + \phi e_j} q_i^2 - e_i \\ &= \left(A + w - q_i - \beta q_j\right) q_i - \frac{1}{e_i + \phi e_j} q_i^2 - e_i, \qquad i = 1,2 \end{aligned} \tag{2}$$

The Nash equilibrium of this game must satisfy the following first order conditions;

$$\frac{\partial V_i}{\partial q_i} = \frac{\partial\left(R_i + w_i\right)}{\partial q_i} = 0, \quad i, j = 1,2 \tag{3.1}$$

and

$$\frac{\partial V_i}{\partial e_i} = \frac{\partial\left(R_i + w_i\right)}{\partial e_i} = 0, \quad i, j = 1,2 \tag{3.2}$$

which is equivalent to these set of equations;

$$\left(A + w - q_i - \beta q_j\right) - q_i - \frac{2}{e_i + \phi e_j} q_i = 0, \qquad i, j = 1,2 \tag{4.1}$$

$$\Leftrightarrow A + w - 2q_i - \beta q_j - \frac{2}{e_i + \phi e_j} q_i = 0, \qquad i, j = 1,2 \tag{4.1'}$$

and

$$\frac{1}{\left(e_i + \phi e_j\right)^2} q_i^2 - 1 = 0, \qquad i, j = 1,2 \tag{4.2}$$

The only economically admissible solution of equation (4.2) is;

$$q_i = e_i + \phi e_j, \qquad i, j = 1,2 \tag{5}$$

Substituting the value of q_i and q_j from (5) into (4.1)' yields;

$$A+w-\beta\left(e_j+\phi e_i\right)-2\left(1+\frac{1}{e_i+\phi e_j}\right)\left(e_i+\phi e_j\right)=0, \quad i,j=1,2$$

$$\Leftrightarrow A+w-\beta\left(e_j+\phi e_i\right)-2\left(\left(e_i+\phi e_j\right)+1\right)=0, \quad i,j=1,2 \tag{6}$$

We have the following equation set;

$$\left(A+w-2\right)-\left(\beta+2\phi\right)e_j-\left(\phi\beta+2\right)e_i=0, \quad i,j=1,2 \tag{7}$$

From (7) we have the reaction function of each player, given by the following relationship;

$$e_i=\frac{A+w-2}{\phi\beta+2}-\frac{\beta+2\phi}{\phi\beta+2}e_j, \quad i,j=1,2 \tag{8}$$

By solving the system of equations (8), we have the symmetric equilibrium innovation with spillover rate ϕ;

$$e^{NI}=\frac{A+w-2}{\left(1+\phi\right)\left(2+\beta\right)} \tag{9}$$

The corresponding unique symmetric Nash equilibrium production is;

$$q^{NI}=\frac{A+w-2}{2+\beta} \tag{10}$$

<u>Appendix.2</u>; Derivation of the Equilibrium Outcome of "Integration" Regime

The <u>joint monetary profit</u> function is expressed as a function of q_i and q_j and e, and is given by;

$$R^I\left(e,q_i,q_j\right)=R_i\left(e,q_i\right)+R_j\left(e,q_j\right) \tag{11}$$

which is equivalent to the following equation;

$$R^I\left(e,q_i,q_j\right)=\sum p_i q_i-\sum\frac{1}{\left(1/2\right)\left(1+\phi\right)e}q_i^2-e \tag{12}$$

The first order conditions of the joint monetary profit maximization are given by;

$$\frac{\partial R^I\left(e,q_i,q_j\right)}{\partial q_i}=0, \quad i,j=1,2 \tag{13.1}$$

and

$$\frac{\partial R^I\left(e,q_i,q_j\right)}{\partial e}=0 \tag{13.2}$$

yielding the following set of equations;

$$\sum\partial\left(A-q_i-\beta q_j\right)q_i\Big/\partial q_i-\frac{2}{\left(1/2\right)\left(1+\phi\right)e}q_i=0; i,j=1,2 \tag{14.1}$$

$$\Leftrightarrow \partial\left(A-q_i-\beta q_j\right)q_i\Big/\partial q_i+\partial\left(A-q_j-\beta q_i\right)q_j\Big/\partial q_i-\frac{2}{\left(1/2\right)\left(1+\phi\right)e}q_i=0; i,j=1,2 \quad \text{(14.1)'}$$

and;

$$\frac{1}{(1/2)(1+\phi)e^2}q_1^2+\frac{1}{(1/2)(1+\phi)e^2}q_2^2=1 \tag{14.2}$$

These equations reflect the "internalization of externalities" by $q_i, i = 1, 2$ and e. Symmetric equilibrium solutions imply

$$A-2(1+\beta)q-\frac{2}{(1/2)(1+\phi)e}q=0 \tag{15.1}$$

and;

$$\frac{2}{(1/2)(1+\phi)e^2}q^2=1 \tag{15.2}$$

The only economically admissible solution of (15.2) has;

$$q=\frac{e}{2}\sqrt{1+\phi} \tag{16}$$

Substituting (16) into (15.1), we have;

$$A-(1+\beta)e\sqrt{1+\phi}-\frac{2}{\sqrt{1+\phi}}=0 \tag{17}$$

which yields the following innovation level, decided by the "professional manager";

$$e^I=\frac{1}{(1+\beta)\sqrt{1+\phi}}\left[A-\frac{2}{\sqrt{1+\phi}}\right] \tag{18}$$

The corresponding aggregate production level is;

$$q^I=\frac{1}{(1+\beta)}\left[A-\frac{2}{\sqrt{1+\phi}}\right] \tag{19}$$

Appendix 3: Derivation of the Equilibrium Outcome of "Joint Surplus Maximization" Regime

The joint surplus function is expressed as the total sum of the monetary profit function and the private benefit one, and is given by;

$$\Pi^{JS}=R^I(e,q_i,q_j)+w_i(q_i)+w_j(q_j) \tag{20}$$

which is equivalent to the following equation;

$$R_i(e,q_i)+R_j(e,q_j)+w(q_i+q_j)=\sum(p_i+w)q_i-\sum\frac{1}{(1/2)(1+\phi)e}q_i^2-e \tag{21}$$

The first order conditions of the joint surplus maximization are given by;

$$\frac{\partial\Pi^{JS}(e,q_i,q_j)}{\partial q_i}=0,\quad i,j=1,2 \tag{22.1}$$

and

$$\frac{\partial \Pi^{JS}\left(e,q_i,q_j\right)}{\partial e}=0 \tag{22.2}$$

yielding the following set of equations;

$$\sum \partial\left(A+w-q_i-\beta q_j\right)q_i/\partial q_i-\frac{2}{(1/2)(1+\phi)e}q_i=0;\ i,j=1,2 \tag{23.1}$$

$$\Leftrightarrow \partial\left(A+w-q_i-\beta q_j\right)q_i/\partial q_i+\partial\left(A+w-q_j-\beta q_i\right)q_j/\partial q_i-\frac{2}{(1/2)(1+\phi)e}q_i=0; i,j=1,2 \tag{23.1$'$}$$

and

$$\frac{1}{(1/2)(1+\phi)e^2}q_1^2+\frac{1}{(1/2)(1+\phi)e^2}q_2^2=1 \tag{23.2}$$

These equations reflect the "internalization of externalities" by q_i,i = 1, 2 and e.
Symmetric equilibrium solutions imply

$$A+w-2(1+\beta)q-\frac{2}{(1/2)(1+\phi)e}q=0 \tag{24.1}$$

and;

$$\frac{2}{(1/2)(1+\phi)e^2}q^2=1 \tag{24.2}$$

The only economically admissible solution of (24.2) has;

$$q=\frac{e}{2}\sqrt{1+\phi} \tag{25}$$

Substituting (25) into (24.1), we have

$$A+w-(1+\beta)e\sqrt{1+\phi}-\frac{2}{\sqrt{1+\phi}}=0 \tag{26}$$

which yields the following innovation level, decided by the "professional manager";

$$e^{JS}=\frac{1}{(1+\beta)\sqrt{1+\phi}}\left[A+w-\frac{2}{\sqrt{1+\phi}}\right] \tag{27}$$

The corresponding aggregate production level is;

$$q^{JS}=\frac{1}{(1+\beta)}\left[A+w-\frac{2}{\sqrt{1+\phi}}\right] \tag{28}$$

Appendix 4: Proof of Proposition 4.2

(A) The comparison of productions between "Non-Integration" and "Integration" is;

$$q^{NI} = \frac{A+w-2}{2+\beta} \geq \frac{1}{2(1+\beta)}\left[A-\frac{2}{\sqrt{1+\phi}}\right] = \overline{q}^{I} \Leftrightarrow \frac{2(1+\beta)}{2+\beta}\frac{[A+w-2]}{\left[A-2/\sqrt{1+\phi}\right]} \geq 1$$

When $\beta \geq 0$, a sufficient condition for the above condition is $w \geq 2\left(1-1/\sqrt{1+\phi}\right)$.
We also know that for all $0 \leq \phi \leq 1$, $w \geq 0$

$$q^{DF} = \frac{1}{2+\beta}\left[A+w-\frac{2}{\sqrt{1+\phi}}\right] \geq \frac{1}{2+\beta}[A+w-2] = q^{NI}$$

Hence, if $\beta \geq 0$ and $w \geq 2\left(1-1/\sqrt{1+\phi}\right)$, then we have $q^{DF} \geq q^{NI} \geq \overline{q}^{I}$.

Next, we consider the $\beta \leq 0$ case. The comparison of productions is;

$$q^{DF} = \frac{1}{2+\beta}\left[A+w-\frac{2}{\sqrt{1+\phi}}\right] \leq \frac{1}{2(1+\beta)}\left[A-\frac{2}{\sqrt{1+\phi}}\right] = \overline{q}^{I} \Leftrightarrow w \leq \frac{-\beta}{2(1+\beta)}\left[A-\frac{2}{\sqrt{1+\phi}}\right]$$

and

$$q^{NI} = \frac{A+w-2}{2+\beta} \leq \frac{1}{2(1+\beta)}\left[A-\frac{2}{\sqrt{1+\phi}}\right] = \overline{q}^{I} \Leftrightarrow w \leq \frac{2+\beta}{2(1+\beta)}\left[A-\frac{2}{\sqrt{1+\phi}}\right]-(A-2)$$

Then, we find that;

$$\frac{-\beta}{2(1+\beta)}\left[A-\frac{2}{\sqrt{1+\phi}}\right] \leq \frac{2+\beta}{2(1+\beta)}\left[A-\frac{2}{\sqrt{1+\phi}}\right]-(A-2) \Leftrightarrow A-2 \leq A-\frac{2}{\sqrt{1+\phi}}, \text{ for } 0 \leq \phi \leq 1$$

Therefore, we always have $q^{NI} \leq \overline{q}^{I}$, when $q^{DF} \leq \overline{q}^{I}$ holds. Further we already have $q^{DF} \geq q^{NI}$. Hence, we have $q^{NI} \leq q^{DF} \leq \overline{q}^{I}$. And the condition $q^{DF} \leq \overline{q}^{I}$ tends to be satisfied as w is smaller, and as ϕ is close to 1.

(B) From the result of the table, we find that the ratios between e^{I} and e^{DF} are equal to

$$\frac{e^{I}}{e^{DF}} = \frac{1+\beta/2}{1+\beta}\cdot\frac{A-2/\sqrt{1+\phi}}{A+w-2/\sqrt{1+\phi}}.$$

If $\beta > 0$ (substitutable goods), we immediately have that $e^{I}/e^{DF} < 1$, i.e., R&D innovation e^{DF} in "Decentralized Firm" is greater than the one e^{I} in "Integration". However, if $\beta < 0$ (complementary goods), it critically depends on the relative size of the degree of complementarity β and the size of the private benefit w. As w is relatively greater, e^{DF} tends to be greater than e^{I}. We also have

$$\frac{e^{NI}}{e^{I}} = \frac{1+\beta}{(2+\beta)\sqrt{1+\phi}}\cdot\frac{A+w-2}{A-2/\sqrt{1+\phi}}$$

So, the question on whether Integration increases R&D innovation more than Non-Integration depends on the trade-off between the internalization of externality (the rate of technological spillover) ϕ and the size of the private benefit w.

(C) The result that $\overline{q}^{I} \leq q^{JS}$ and $e^{I} \leq e^{js}$ for $w \geq 0$ and $0 \leq \phi \leq 1$ is obvious from the table. The intuition is that in the joint surplus maximization regime the effect of the private benefit is internalized, while in the "Integration" regime it is ignored.

From the result of the table, we also find that the ratios between q^{DF} and q^{JS}, and between e^{DF} and e^{JS} are equal to

$$\frac{q^{DF}}{q^{JS}} = \frac{e^{DF}}{e^{JS}} = \frac{2(1+\beta)}{2+\beta} \begin{cases} \geq 1 & \text{for } \beta \geq 0 \\ \leq 1 & \text{for } \beta \leq 0 \end{cases}$$

Since $\beta \geq 0$ indicates that the goods of the two units are substitutable, this can be easily understood based on a comparison between the Cournot-Nash behavior (in the 'Decentralized Firm' regime) and the internalization of externalities brought about by the productive activities (in the 'Joint Surplus Maximization' regime). The reasoning is similar for $\beta \leq 0$ (complementary goods case).

(D) This is due to the fact that $\dfrac{q^{JS}}{q^{NI}} = \dfrac{2+\beta}{2(1+\beta)} \cdot \dfrac{A+w-2/\sqrt{1+\phi}}{A+w-2}$.

The intuition is that in the joint surplus maximization regime, the externality effect of production q is internalized, while it is not considered in the "Non-Integration" regime. It brings about a direction towards more output expansion in the "Non-Integration" regime when $\beta > 0$. But, the spillover effect ϕ is internalized only in the joint surplus maximization regime. This leads to more output expansion through greater cost reductions. Next, when $\phi = 0$, we have

$$q^{NI} = \frac{A+w-2}{2+\beta}, \overline{q}^{I} = \frac{A-2}{2(1+\beta)}, \text{ and } q^{JS} = \frac{A+w-2}{2(1+\beta)}$$

This gives the above result. $q^{NI} > q^{JS}$ comes from the internalization of the negative externality on production q, and $q^{JS} > q^{I}$ is due to the fact that in the "Integration" regime private benefits are ignored by the top manager.

Appendix 5: Proof of Proposition 5

Suppose that an *enforceable* contract is possible between two local (divisional) managers. Now consider delegating the authorities of production activities to them, thereby letting them choose production activities *cooperatively*. Given that the professional manager chooses R&D activity e, two local (divisional) managers cooperatively maximize the joint surplus function Π^{JS}

$$\begin{aligned} \max_{\{q_i, q_j\}} \Pi^{JS} &= R^{I}(e, q_i, q_j) + w_i(q_i) + w_j(q_j) \\ &= R_i(e, q_i) + R_j(e, q_j) + w(q_i + q_j) \end{aligned}$$

Given that two local (divisional) managers cooperatively maximize the joint surplus, the professional manager chooses R&D activity e in order to maximize the monetary total profit R^{I}.

$$\max_{\{e\}} R^{I}(e, q_i, q_j) = R_i(e, q_i) + R_j(e, q_j)$$

The first order conditions are given by;

$$\frac{\partial \Pi^{JS}\left(e,q_i,q_j\right)}{\partial q_i}=0,\quad i,j=1,2$$
$$\frac{\partial R^{I}\left(e,q_i,q_j\right)}{\partial e}=0$$

We have;

$$\partial\left(A+w-q_i-\beta q_j\right)q_i\big/\partial q_i+\partial\left(A+w-q_j-\beta q_i\right)q_j\big/\partial q_i-\frac{2}{\left(1/2\right)\left(1+\phi\right)e}q_i\ =0;i,j=1,2$$

And

$$\frac{1}{\left(1/2\right)\left(1+\phi\right)e^2}q_1^2+\frac{1}{\left(1/2\right)\left(1+\phi\right)e^2}q_2^2=1$$

These equations reflect the "internalization of externalities" by q_i,i = 1, 2 (cooperatively chosen by two local managers) and e (chosen by professional manager).
At symmetric solutions, we have from the first equations,

$$A+w-2\left(1+\beta\right)q-\frac{2}{\left(1/2\right)\left(1+\phi\right)e}q=0\Leftrightarrow q=\frac{A+w}{2\left[\left(1+\beta\right)+\dfrac{2}{\left(1+\phi\right)e}\right]}$$

This is the optimal reaction function by the cooperative two local managers against the R&D activity e.
The only economically admissible solution of the second first order condition is $e=\dfrac{2q}{\sqrt{1+\phi}}$, which is the optimal reaction function by the professional manager against the cooperative production activities q. From the simple calculation, we see that the first best allocation can be implemented as a Nash equilibrium in a non-cooperative game between the union of two local managers and the professional manager).

$$e_{LMs}^{D}=e^{JS}=\frac{1}{\left(1+\beta\right)\sqrt{1+\phi}}\left[A+w-\frac{2}{\sqrt{1+\phi}}\right],\ q_{LMs}^{D}=q^{JS}=\frac{1}{2\left(1+\beta\right)}\left[A+w-\frac{2}{\sqrt{1+\phi}}\right]$$

This is an interesting theoretical remark, but, since any *enforceable* contract is impossible between two local (divisional) managers and actions must be chosen in a *self-enforcing* way, this solution is impossible.